SEASONALITY IN A FORAGING SOCIETY: VARIATION IN DIET, WORK EFFORT, FERTILITY, AND SEXUAL DIVISION OF LABOR AMONG THE HIWI OF VENEZUELA[1]

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In this paper we describe seasonal variation in the diet, subsistence work effort, and sexual division of labor among Hiwi foragers of Venezuela. The major findings are: (1) The Hiwi diet is characterized by stability in hunted resources but extreme seasonality in vegetable resource types. (2) Men and women show significant seasonal variations in subsistence work effort and, therefore, in the character of the sexual division of labor. (3) Significant seasonal weight changes for each sex are observed. (4) Female fertility patterns vary seasonally, and this variation appears to be highly correlated with changes in "net" energy intake throughout the year. We suggest that a consideration of the individual fitness consequences of behavioral options for each sex may provide some insight into sex differences in behavior across seasons.

SEASONALITY HAS LONG been considered an important factor affecting human societies. Because seasonality influences the food supply, and this in turn constrains many other aspects of economic and social life, simple changes in rainfall and temperature patterns can result in an almost endless array of subsequent ramifications that may ultimately influence work patterns, marriage, social structure, and ritual cycles. In addition, seasonal extremes in food supply or weather conditions may represent the most important constraints on long-term physical and behavioral adaptations (Liebig's Law of the Minimum). Thus studies of extreme seasonal conditions among hunter-gatherers may provide useful insights into the selective pressures responsible for the evolution of a wide variety of human characteristics.

While the appreciation of economic seasonal trends in agricultural groups is generally unavoidable because of planting and harvesting cycles (e.g., Dugdale and Payne 1987), few quantitative studies of seasonality in foraging (hunting-gathering) societies have been published (Wilmsen 1982; Bailey and DeVore 1989; Hill et al. 1984). This is surprising given that many ethnographers have been quite explicit about the importance of seasonality among foragers. Studies suggest that seasonality affects patterns of diet, work effort, group size, mobility, warfare, and ritual on all continents and at all latitudes (e.g., Africa: Silberbauer 1981; Lee and DeVore 1976; Hawkes, O'Connell, and Blurton Jones 1989; Asia: Cipriani 1961; Griffin 1984; Eder 1968; Watanabe 1968; Australia: Meehan 1975, 1982; D. Thomson 1983; North America: Steward

1938; Downs 1966; Hoebel 1978; Damas 1972; South America: Holmberg 1950; Gusinde 1961; Dieter 1972). The most common patterns reported are that changes in the seasonal abundance of some food resources promote shifts from small mobile social groups to large sedentary ones, thus influencing mating patterns and ritual activity. Regular seasons of bad weather also appear to limit travel, visiting, and intergroup conflict.

In the most extreme description of seasonal effects, Donald Thomson's 1939 study in Arnhem Land suggested that differences between the wet and dry seasons in group size, mobility, diet, tool usage, and ritual activity were so pronounced that a naive observer might easily conclude he was observing two different "tribes" of people (D. Thomson 1983). In contrast, our own studies of seasonality among the Ache of Paraguay suggested that changes in rainfall and temperature had only minor effects on diet and activity patterns (Hill et al. 1984; Hill 1983:210).

Most previous research on seasonality among subsistence agriculturalists and hunter-gatherers has focused on food consumption (Fox 1953; Calloway 1982a; Dugdale and Payne 1987). This is not only because energy and protein intake is an important determinant of long-term population and individual variation in nutritional status, but because poor diets also generally have negative effects upon children's growth rates (Flowers 1983; Billewicz 1967; McGregor, Billewicz, and Thomson 1961; A. Thomson 1977) and, ultimately, upon various biological components of fitness such as fecundity (Crook and Dyson 1981; Becker, Chowdhury, and Leridon 1986) and child mortality (Brown et al. 1985; Chambers, Longhurst, and Pacey 1981:103–34).

Although dietary variation is often described, work seasonality has been studied relatively less, even though adequate energy balance is the product of both dietary intake and energy expenditure. Indeed, work effort differences may be more important than food consumption when the individual members of a society are examined. Although food is often pooled to some extent, especially between spouses in a nuclear family, work patterns are very sex specific. A review of the literature on hunter-gatherers shows that there are marked differences in adult male and female subsistence strategies in all groups studied and that the extent of these differences appears to be affected by seasonal changes in the local ecology (Hurtado 1985).

To the extent that male and female subsistence behaviors differ, and to the extent that these differences have consequences for food consumption and energy expenditure, food and work seasonality are likely to affect differentially the health status of the sexes in foraging societies. Sex differences in energy expenditure across seasons coupled with temporal fluctuations in energy intake may produce peaks and troughs in female and/or male fertility (see Ellison 1989 for a review). Although seasonal changes in the diet or work effort and their effects on the weights of adult males and females have been reported for some groups of foragers (e.g., Wilmsen 1982; Hill et al. 1984; Hawkes, O'Connell, and Blurton Jones 1989), the relationship between seasonal fluctuations in caloric consumption, sex differences in time spent foraging, health status, and fertility has not been systematically studied in foraging societies. The literature on societies with more complex social structures provides little insight into this problem: although seasonal fluctuations in birth rates appear to be a universal phenomenon in human societies (see Leslie and Fry 1989 and references therein), our current understanding of the causes of this variation is very poor.

Finally, the opportunities for natural experimentation that are facilitated by seasonal variability have not been fully appreciated in behavioral studies of hunter-gatherers. Since many of the important dependent variables of interest (e.g., sexual division of labor, group size, mobility) show seasonal changes, it is hoped that the relevant independent variables responsible for these patterns will be discovered by examining seasonal changes. These descriptive associations can then be used to develop models specifying the relationship between ecological conditions and behavioral outcomes. The stratification of behavioral observations according to seasonal changes in the independent variable of interest allows us to test these models. Thus an examination of seasonality presents an exciting opportunity for testing propositions concerning the temporal and spatial distribution of behavior.

In this paper we describe seasonal variation in the diet, subsistence work effort, and character of the sexual division of labor among Hiwi foragers.[2] We also describe seasonal fluctuations in adult weights and in women's fertility and consider factors associated with this variation. We discuss several issues that arise and suggest that a consideration of the available alternatives and the individual fitness consequences of each behavioral option for each sex may provide some insight into these puzzles.

BACKGROUND

The sexual division of labor, ethnographic background, and diet of Venezuelan and Colombian Hiwi populations have been partially described in several publications (Coppens 1975; Fonval 1976; Arcand 1976; Hurtado and Hill 1986, 1987). Preliminary analyses of demographic data have also been published (Hurtado and Hill 1987).

This paper describes seasonal variation in the subsistence strategies of Hiwi hunter-gatherers of southwestern Venezuela.[3] This population lives in the extremely seasonal neotropical savannas of the Orinoco River basin (Cole 1986), where a larger population of closely related Guahibo-speaking peoples resides. Although all the Guahibo-speaking populations refer to themselves as "Hiwi," in this paper the term "Hiwi" is used to refer exclusively to the hunting and gathering bands of the Guahibo population, as no other adequate label is available. For these bands, the local *criollo* populations use the term "Cuiva," which has strong derogatory connotations.

Even though the Hiwi are linguistically and culturally similar to other Guahibo groups, their economic patterns are quite different (see Metzger and Morey 1983 for reviews). Most Guahibo speakers are subsistence agriculturalists residing along the alluvial plains of the lower Meta, Tomo, Tuparro, and Vichada rivers in Colombia and along the middle Orinoco River between the Villacoa and Cuao rivers (Metzger and Morey 1983). In contrast, the territory of the Hiwi, who have been described since earliest reports as nonagriculturalist hunter-gatherers, is confined to the drainages of the upper Cinaruco, Capanaparo, Cinaruco, Ariporo, Agua Clara, and Meta rivers. The spatial distribution of Guahibo-speaking agriculturalists and Hiwi foragers may be determined in part by soil type, drainage, and the size of alluvial plains: Hiwi foragers inhabit poorly drained, clayey savannas and river headwaters, while agriculturalists occupy well-drained, sandy savannas and gallery forests along the lower courses of rivers, where alluvial plains are more extensive (Cochrane et al. 1985).

ECOLOGICAL AND SOCIAL FACTORS

Social, ecological, and historical factors play an important role in the contemporary behavior of Hiwi hunter-gatherers. The Hiwi inhabit a neotropical savanna (*llanos*) that floods annually. Flooding is followed by a dry spell that lasts several months. The ecological consequence of this rainfall regime is a marked fluctuation in the temporal and spatial distribution and in the biomass and productivity of plants and animals.

The llanos are characterized by extensive grasslands, with belts of gallery forests one to two kilometers in width found along main rivers and some creeks. Their major boundaries include the Venezuelan Andes, the coastal mountain range (Cordillera de la Costa), the Orinoco River, and the Vichada River (the border of the Amazon tropical forest). The main territory of the Venezuelan Hiwi is confined to areas contiguous to the Cinaruco River.[4]

Rainfall, Temperature, and Soils

One of the most important ecological features of the llanos is their unimodal rainfall seasonality. Close to 90 percent of the precipitation falls during the months of May through November, followed by an intervening period of severe moisture stress between January and March. During these dry months, monthly precipitation averages fall below 25 millimeters (MARNR 1987; see Troth 1979:18), and often there is no rain in January and February (Figure 1). The north wind blows almost constantly, lakes and lagoons dry up completely, and savanna grasslands wither and die.

Temperatures are relatively constant throughout the year, with a difference of only 1.9° C between the mean daily temperature of the coldest and warmest month. Mean extreme temperatures are somewhat variable, however, ranging from an average daily maximum of 37.7° C in March to an average daily minimum of 19° C in December (Troth 1979:19) (Figure 2).

The soils of the Venezuelan llanos are generally acidic, sandy, deficient in potassium, and poorly drained, with little potential for agricultural production.

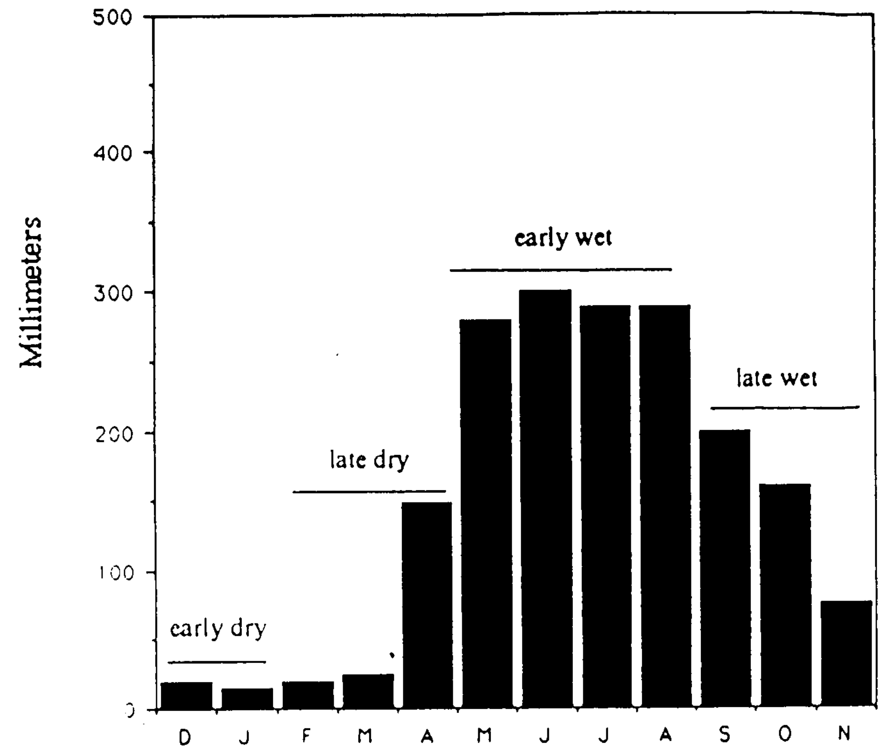

Figure 1. Mean Monthly Rainfall in the Lower Llanos (from MARNR 1987)

The Spatial and Temporal Distribution of Wild Foods

In the lower llanos, microrelief and degree of inundation are responsible for the uneven and patchy distribution of floral and faunal species. Ecologists have identified five physiographic units in the Venezuelan llanos: *médano* (sandhill), *banco* (nonflooded, low ridge), *bajío* (moderately flooded lowlands), *estero* (more deeply flooded lowlands), and gallery forests (Troth 1979). The gallery forests are well drained and flood minimally.

These physiographic units are differentially exploited for food and other resources by the Hiwi. The médanos are important for the palm *Mauritia minor*, an important source of food staples and materials (palm fruits, palm heart, and leaves and wood for manufacturing baskets, bags, and bows). During the dry season, bajíos and esteros are the primary foraging ground of grazers such as deer and capybara, and during the wet season when the savannas flood, fish exploit abundant palatable grass species at these sites (see Troth 1979:27). One of the Hiwi's more important carbohydrate staples, the "oyo" tuber (*Banisteriopsis* sp.), grows in extensive patches in bajíos and esteros. Other tubers are found in dense clumps along the transitional zone between

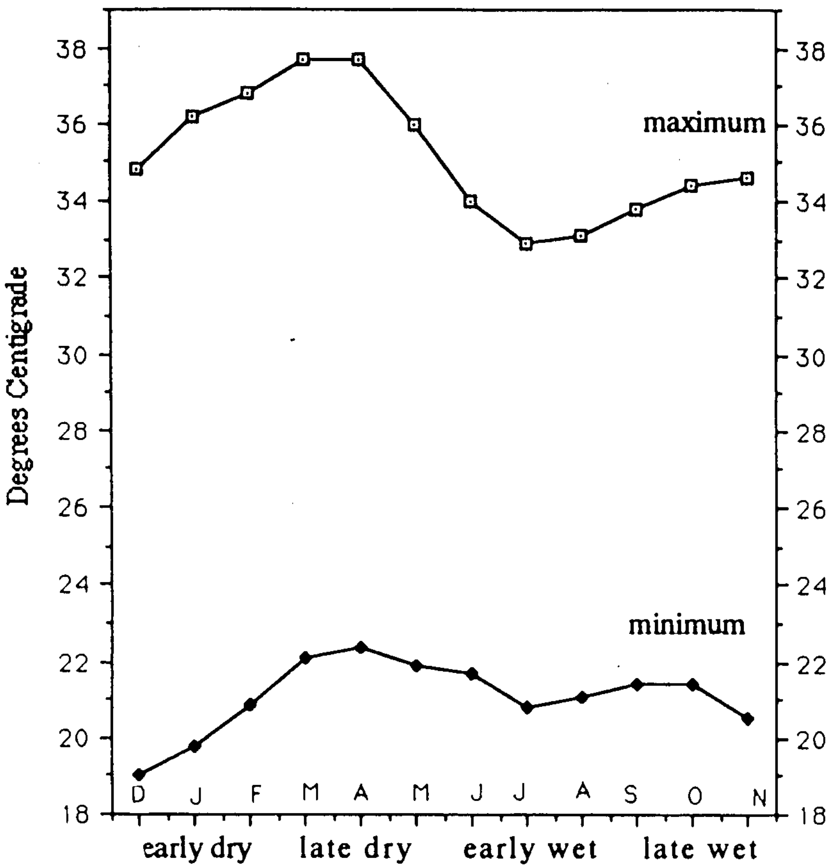

Figure 2. Mean Monthly Temperature in the Lower Llanos of Venezuela

the gallery forest and the savanna (e.g., *Dracontium asperum, Calathea allonia,* and *Cannas edulis*). Fruiting trees are primarily found in the gallery forest, while legume-producing trees (mainly *Campsiandra comosa*) grow along the edge of the gallery forest that faces the riverbanks.

Changes in the water level have important consequences for the distribution of faunal species across seasons. When the waters recede during the dry season, fish remain trapped in pools that are formed in the bajíos and esteros. These water sources also become attractive grounds for caiman, capybaras, and turtles. The animal biomass of these ponds during the dry season is quite high (Eisenberg 1979) and becomes a primary hunting target of Hiwi hunters.

In contrast, flooding during the wet season disperses fish, turtles, and caiman over huge expanses of savanna, while large mammals (deer, capybaras, peccaries, and anteaters), on the other hand, seek refuge in gallery forests. Not surprisingly, the gallery forest becomes the preferred foraging ground for the Hiwi during this time of the year. During both seasons of the year, canoes are

the major form of transport to hunting patches. Canoes are also frequently used in the pursuit of riverine and semiaquatic game.

Group and Territory Size

The Hiwi population of both Venezuela and Colombia in the 1980s is unknown, primarily because of the social chaos brought on by drug trafficking and guerrilla warfare along the Colombian and Venezuelan border in recent years. In the 1970s, however, Arcand (1976) estimated that the total Hiwi population in both countries was approximately 800 individuals.

The population of the Venezuelan Hiwi hunter-gatherers was 290 individuals in the 1988 dry season. These individuals comprise two semipermanent residential bands which are further subdivided into factions. The bands form very large camps including all members of the band during much of the year, but they also break up into smaller bush camps for periods of up to four weeks at a time. The two residential settlements are located near the Cinaruco River within a four-hour walk of each other on a reserve bounded by two rivers and an incipient cattle ranch; in 1971 a presidential decree set aside 12,058 hectares for the reserve (Hurtado 1986).

The larger band (188 individuals), which we refer to as the Jicutimene band, is settled in the middle of a dry savanna next to the local Indian services office (see Hurtado and Hill 1986, 1987). The smaller band (102 individuals), which we refer to as the Cinaruco band, prefers to live in the gallery forest along the Cinaruco River. Its central place has been moved several times over the past twenty years. Logistical difficulties have curtailed all attempts to implement economic, medical, and social programs in this second band. This more isolated group of Hiwi, the Cinaruco band, is the focus of our investigations.

Social Organization

The nuclear family plays an important economic and social role in Hiwi society. Preliminary analyses of demographic data suggest that the Hiwi form long-lasting marital bonds that are usually monogamous. In addition, food distribution observations indicate that plant and animal resources are preferentially shared within the nuclear family of the acquirer or with close kin (Lyles, Hill, and Hurtado 1990). At the same time, time allocation data suggest that married couples spend a great deal of time together, both in camp and out of camp, and that they frequently cooperate in food acquisition activities. This pattern is in striking contrast to other native South Americans that we have observed and was noted by Arcand as well.[5] The extent of cooperation between couples varies greatly across seasons.

Cooperation beyond the nuclear family also appears to be heavily influenced by kin relationships. Alliances between families divide the villages into various factions. As seasons, settlement, and movement patterns change, these factions make predictable moves into and out of the village throughout the year. Even though Hiwi villages choose only one leader to represent them in confrontations with other villages, several men within the village appear to informally represent these loosely organized factions in intravillage politics.

HISTORICAL FACTORS

The first peaceful contact between cattle ranchers and Venezuelan Hiwi took place in 1959. The ranchers who initiated contact hoped to end the frequent violent encounters and incidents of cattle theft that had characterized interethnic relations in the area since the early 1900s. They were also interested in obtaining inexpensive labor that they believed the Hiwi might provide. Two bands of Hiwi, whose traditional territories were located about a hundred kilometers apart, were convinced to settle together in the Cinaruco band's territory because it was closest to a criollo village. In return, the Hiwi were offered protection from the violent incursions of other cattle ranchers. The Hiwi were easily convinced; within a few months of peaceful contact, a band of approximately thirty individuals who failed to move to the protected area was massacred along the upper Cinaruco River.

By agreeing to live relatively close together along the same river, the two Hiwi bands may have compromised access to a larger food supply. According to informants, the immigrant group was relegated to the less productive habitats, while the resident group, to this day, is in control of most of the best foraging patches. Over the years, the two groups have staked out two "territories" within their land reserve and adjacent riverine areas, and they forage almost exclusively within their own territory. Members of either band are sometimes beaten or killed when encountered in the neighboring band's territory. The larger newcomer band forages downstream from their settlement and along all downstream tributaries for about 40 kilometers to the south of the settlement of the resident band. The smaller resident band forages upstream for about 50 kilometers to the headwaters of the Cinaruco. Hostile interactions and overt warfare between the two groups have been the norm since at least 1974; sporadic killings have taken place as late as 1986.

In conclusion, a highly seasonal savanna environment and a shrinking food resource base probably shape the subsistence patterns of Hiwi hunter-gatherers in important ways. We describe below the behavior of Hiwi men and women and some of the constraints imposed by this ecological setting.

METHODS

The Study Site

Food acquisition, anthropometric, and demographic data were collected among the band of Hiwi which resides in the gallery forest. The behaviors of adult Hiwi were sampled at two different sites: first, in 1985–86, at the Estéban location (Hurtado and Hill 1987), and then, in 1987–88, at their most recent settlement. This relocation was prompted by a devastating raid and one homicide executed by members of the enemy Hiwi band. Because the Cinaruco band that we chose to study occupies the more abundant sectors of the Hiwi territory, mobility and dispersal are less pronounced than among the other

band. Consequently, we were able to do most of our data collection at a central place and on a larger number of people on any given sample day than would have been possible among the more nomadic inhabitants of the savanna settlement. It is important to emphasize that the behavioral profile described here is *restricted to a central-place settlement only*. Data analyses of subsistence behaviors in temporary, small bush camps will be discussed elsewhere. On 85 percent of all Hiwi person-days, individuals slept in the central place settlement; on 8 percent of all person-days, they slept in temporary camps; on 4 percent, they worked in nearby cattle ranches; and on 3 percent of sample days, they attended celebrations at a local criollo village.

Data Collection

The analyses described here are based on data collected in November and December 1985, April 1986, July 1987 and 1988, and from December 1987 until May 1988, for a total of 185 days in residence at the field site. The actual dates of sampling during field periods over the four years of this study are shown in Tables 1 and 2 (see below). For the study on seasonal changes in food consumption, foraging behaviors of adults, nutritional status, and reproduction, we collected data on time allocation, food acquired, edible portions, adult weights, and birth seasonality.

Collection of the first three types of data involved noting all individuals who left camp and with whom they left (analyses of in-camp activities will be reported elsewhere). We recorded their departure and arrival times and the main subsistence activity in which they were involved. Foods were weighed with Homs spring scales (1, 5, 10, 25, and 50 kilograms) when individuals arrived in camp, and the weights were entered in the data notebook. The scales were zeroed prior to each day of data collection. Foods weighing less than 500 grams were weighed to the nearest 50 grams, and foods weighing between 500 grams and 10 kilograms were weighed to the nearest 100 grams. Foods weighing more than 10 kilograms were often divided and weighed to an accuracy of 100 grams, although they were occasionally weighed as single packages to the nearest 250 grams. Foods above 20 kilograms were either divided and weighed to the nearest 100 grams or were weighed whole to the nearest half kilogram. Nine percent of all food packages were weighed to the nearest 50 grams, 90 percent were weighed to the nearest 100 grams, and 1 percent were weighed to the nearest half kilogram. Since the median package size was 10 kilograms, the median error of measurement was plus or minus 1 percent.

On a few occasions, representative samples of game and wild plant foods were weighed whole and then again after all processing prior to cooking had been completed. These data were gathered in order to estimate edible proportions of resources. Loss in cooking was not estimated but is generally small since the Hiwi boil much of their food and drink the broth.

All members of the study population were weighed once a month with a Harpenden (Holtain Ltd.) beam scale with a long pillar and nondetachable

TABLE 1
Characteristics of the Sample on Food Consumption: Number of Days and Consumer-Days Sampled

Month/Year (dates)	Number of days sampled	Number of consumer-days sampled	SEASON
January 1988 (8–12, 18–21, 27–31)	14	673	EARLY DRY
February 1988 (1–5, 11, 17, 26, 27)	9	616	LATE DRY
March 1988 (1–4)	4	168	LATE DRY
April 1986 & 1988 (3, 4, 6, 8, 10, 11, 14, 16, 18, 19; 12/1986)	11	761	LATE DRY
May 1988 (2–6, 10, 11, 13–15)	10	389	EARLY WET
July 1987 & 1988 (8/87, 15/88)	2	172	EARLY WET
November 1985 (15–30)	16	1406	LATE WET
December 1985 & 1988 (2–7/85; 14–26, 18, 21/88)	21	450	EARLY DRY
TOTAL	87	4635	

weights. Weights were recorded to the nearest 100 grams. Triceps skinfold thickness and standing height were also measured each month, but those data are not reported here.

Information on the seasonality of conceptions was ascertained in demographic interviews with a bilingual informant who asked women to describe the main food staples at the time of each of their children's births. Our informant, in turn, knew the months of the year when these resources come into season. Due to the high seasonality of tubers, fruits, legumes, turtle eggs, and honey,

TABLE 2
Characteristics of the Sample on Time Spent Foraging per Day: Number of Individuals and Person-Days Sampled

Month/Year (dates)	Number of individuals		Number of person-days sampled	
	males	females	males	females
January 1988 (8–12, 18–21, 27–31)	31	29	218	179
February 1988 (1–5, 11, 17, 26, 27)	31	29	180	179
March 1988 (1–4)	31	29	52	49
April 1986 & 1988 (3, 4, 6, 8, 10, 11, 14, 16, 18, 19; 12/86)	31	29	248	217
May 1988 (2–6, 10, 11, 13–15)	31	29	118	114
July 1987 & 1988 (8/87, 15/88)	31	29	56	50
November 1985 (15–30)	28	28	417	440
December 1985 & 1988 (2–7/85; 14–26, 18, 21/88)	31	29	146	135
TOTAL	—	—	1435	1363

births could be easily matched to months of the year, and independent verification (using births recorded by local officials or the investigators) showed these estimates to be reliably consistent within a range of one to two months.

Tables 1 and 2 describe the characteristics of the samples on food consumption and time spent foraging per day. These tables show the number of days, consumer-days, individuals, and person-days sampled per month and per season.

Definition of Seasons

Seasonal periods in this study reflect the yearly divisions used by the local criollo and Hiwi populations. They are partially defined by rainfall patterns but are more reflective of water levels in the rivers, lagoons, and savanna depressions. Rainfall is generally well above 100 millimeters per month between April and November and well under 100 millimeters per month between December and March. No rain at all falls between January and March, and the north wind blows constantly. Local people, however, include April in the dry season because of the low water levels common throughout that month. Dramatic changes in flooding and drying across the year have an important effect upon the availability and distribution of food and resources, ease of transportation to foraging sites, environmental hazards, and many other ecological parameters. Consequently, the early dry season begins when the savanna starts to dry out and vehicles can traverse it successfully (around the first of December). This season is characterized by a dry savanna with river levels several meters below the highest riverbanks of the local area. Most oxbow lakes and savanna depressions hold water through the early dry season and become important sites for intensive fishing as they shrink in size. The late dry season begins in February and is defined by a complete drying of savanna depressions and all but the deepest oxbow lakes along the rivers. It is considerably drier than the early dry season, with rivers reaching levels which may be more than 20 meters below the high-water level.

Rains begin in mid-April, but the early wet season does not start until about May first, when all vehicles leave the area and the dried ponds and swamps again hold water. The water levels of rivers and ponds begin to rise, but the savanna itself still is generally dry. In the late wet season beginning around September, rivers often overflow even the highest riverbanks in the area. The savanna becomes an extensive unending lagoon, and only a few small islands of dry land are available. In this season both human and other terrestial mammal populations are highly concentrated, and travel by dugout, boat, or plane is the only mode of transportation used in the area. By the first part of December, the waters subside to the point that land vehicles can again enter the area, and the cycle begins anew. The year was thus divided into four periods before data were inspected. These periods are (1) early dry—December and January; (2) late dry—February, March, and April; (3) early wet—May, June, July, and August; and (4) late wet—September, October, and November.

A Note on Work Effort

Throughout this paper, "work" or "foraging effort" only refers to time spent foraging away from camp. Data on other important subsistence activities such as food processing and manufacturing are currently under analysis. Preliminary summary statistics indicate that there are important differences between the sexes and across seasons in time spent in these other activities (unpublished data).

THE HIWI DIET

The relationship between the health status of adults and changes in the sexual division of labor across seasons is examined by first describing the main food staples, their relative caloric contribution to the Hiwi diet, and their differential distribution over the annual cycle. We then investigate the varying contributions of the sexes to food consumption in terms of caloric acquisition and foraging effort and examine the association between these factors, body composition (mainly weights), and female fertility. It is important to emphasize again the the following quantitative descriptions and analyses only include data collected at a large central-place settlement. Analyses of subsistence behavior at temporary bush camps will be presented elsewhere.

The Hiwi exploit a wide variety of animal and wild plant foods in the savanna, gallery forests, rivers, and swamps. The food resources acquired during our study are described in Table 3 and are divided into four major categories: game and fish, wild plant foods, agricultural products, and store-bought foods. This table also lists edible portions and the number of calories per edible kilogram, along with the bibliographic and laboratory sources used to obtain them.

The meat component of the Hiwi diet was primarily derived from six species of mammals (capybara, collared peccary, deer, anteater, armadillo, and feral cattle), numerous species of fish, and three or more species of turtles. In addition, our sample included iguanas and savanna lizards, wild rabbits, and many species of birds.

Capybaras were primarily hunted along riverbanks or in shallow lagoons. Collared peccaries and anteaters, by contrast, were found in the gallery forests, while deer and feral domestic animals were hunted in the savanna–forest edge. Turtles were heavily preyed upon in the late wet season and were killed with either spears or arrows in oxbow lakes along riverbanks. Turtle eggs came into season during January, February, and March and were intensively exploited by tourists, local criollo residents, and the indigenous populations. Although the vast majority of eggs exploited by the Hiwi came from turtles belonging to the genus *Podocnemis*, eggs from other turtles and unidentified species of birds were also acquired.

The Hiwi also gathered five species of roots, a variety of fruits, palm nuts and hearts, a wild legume (*Campsiandra comosa*), and honey produced by various species of bees and, to a lesser extent, wasps.

Agricultural products in the Hiwi diet included plantains, corn, and squash. These staples were grown by some Hiwi families who kept small and widely scattered unproductive fields. Store-bought resources were available at neighboring cattle ranches and at a town approximately 30 kilometers from the Hiwi village, but most store-bought commodities were gifts from either the anthropological team or tourists who come to fish the local rivers and streams. These consisted primarily of inexpensive carbohydrate staples and sweets (rice, noodles, corn flour, and sugar).

Table 4 summarizes the Hiwi diet for the eight months of the year that were sampled. As in Table 3, the resources are divided into four major categories: game and fish, wild plants, agricultural products, and store-bought staples. Because roots were the primary source of carbohydrates, whereas other wild

TABLE 3
Hiwi Food Resources

Scientific name[1]	Description	Calories/ edible kg.	Edible portion[2]	Source[3]	Season
GAME AND FISH:					
Hydrochaeris hydrochaeris	Capybara	1817	.75	D	year round
Milossoma duriventris; Pseudoplastystoma sp.; Hoplias malabariscus; Serrasalmus sp. and others	Fish	960	.75	B	dry season
Caiman cocrodilus	Alligator	1288*	.75	B	dry season
Tayassu tajacu	Collared peccary	1770	.75	A	year round
Odocoelius mazama	Deer	1460	.75	B	year round
Chelus fimbriatus; Podocnemis sp.; Geochelone sp.	Turtles & tortoise	890	.5	B	late wet season
Dasyptus novemcinctus	Armadillo	1540	.75	A&B	early dry season
Iguana iguana; Tupinambis nigropunctatus	Iguana and savanna lizard	1120	.75	B	late wet season
—	Feral domestic cattle	1785**	.75	B	year round
Tamandua tetradactyla	Anteater	1460	.75	D	dry season
Ajaia ajaja; Amazonetta brasiliensis and others	Birds	1700	.75	D	dry season
Sylvilagus fondanus	Rabbit	1590	.75	B	n.a.
—	Bird and turtle eggs	2180	.9	B	turtle eggs-dry season
WILD PLANTS:					
Roots:					
Dracontium asperum	Small wild potato 'Hero'	1200	.9	D	late wet
Banisteriopsis	Wild root (bitter) 'Oyo'	682	.9	D	late wet
Calathea allonia	Wild root (bitter) 'Hewyna'	682	.9	D	early dry
Cannas edulis	Wild root (sweet) 'Yatsiro'	1200	.9	B	late dry
Dioscorea sp.	Wild root (sweet) 'No'o'	1000	.9	B	early dry
Other plants:					
Mangifera indica	Ripe mangos Unripe mangos	590 440	.5	B	late dry/early wet

Continued on next page

Table 3—*Continued*

Scientific name[1]	Description	Calories/ edible kg.	Edible portion[2]	Source[3]	Season
Citrus aurantium	Oranges	393	.9	B	late wet
Miscellaneous	Various fruits	599	.9	B	n.a.
Mauritia minor	'Jojjom' fruit	845	.22	D	early wet
Unidentified	'Guaye' fruit	599	.13	D	early wet
Unidentified	Merei fruit	460	.82	B	early wet
Unidentified	Madroña fruit	599	.4	D	early wet
Mauritia minor	Palm nuts 'Yopijicua'	2960	.33	D	late dry
Mauritia minor	Palm heart	595	1.00	A	late dry
Campsiandra comosa	Legume 'Chiga'	4000	.3	E	early wet
HONEY:					
Unidentified	Honey	2673***	1.00	B	dry season
AGRICULTURAL PRODUCTS:					
Musa sp.	Plantain	1320	.9	B	?
Zea mays	Corn	970	.28	B	?
Cucurbita maxima	Squash	350	.9	B	?
STORE-BOUGHT FOODS:					
—	Rice	3640	1.00	B	dry season
—	Noodles	1107	1.00	B	dry season
—	Sugar	3840	1.00	B	dry season
—	Corn flour	1890	1.00	B	dry season

[1]Faunal species were identified through reference to Sánchez 1981. Floral species identification was provided by Dr. Roberto Lizarralde, Universidad Central de Venezuela, Caracas.

[2]We have only included the edible portions for faunal species used when the animal was weighed whole (i.e., not gutted). All game items weighed already gutted were assumed to have an edible portion of 90%. The edible portion values for some animal prey were measured among the Ache (deer, collared peccary, anteater, capybara, fish) in previous fieldwork (see Hill et al. 1984), while others were measured among the Hiwi (turtles, tortoises, iguanas). The edible portions for vegetable resources were measured at the Hiwi site.

[3]SOURCE A—Analyses of foods acquired by the Ache of Eastern Paraguay conducted by Ford Chemical Laboratory, Salt Lake City, Utah; B—Handbook of Latin American Foods (Leung 1961); C—USDA Handbooks 8 and 456; D—extrapolated from similar items listed in A, B, or C (see Hill et al. 1984: Table 2); E—Sánchez et al. 1987.

*Only caloric values for dried alligator meat were found. Based on a 180 percent increase in caloric content between raw and dried beef, we estimated this value for raw caiman meat (source B).

**Leung (1961) lists 1130 calories per kilogram of very thin edible beef. This seems to be a very low estimate given the higher caloric values we have found for wild animals. Consequently, here we use the mean calories per kilogram reported for medium fat and very thin in the same table.

***Measured in liters.

TABLE 4
The Hiwi Diet
Months Sampled: November–May and July; Sampling Period: 1985–88

Resource name (cals/kg)	Amount (kgs)*	Total calories[1]	Mean daily per Capita consumption of calories[2]	Percent of the diet
GAME AND FISH				
Feral domestic cattle (1785)	1,350	2,409,750	520	
Capybara (1817)	730	1,326,410	286	
Fish (960)	1,035	993,600	214	
Caiman (1288)	392	504,896	109	
Collared peccary (1770)	163	352,080	76	
Deer (1460)	136	198,560	43	
Turtles (890)	185	164,650	36	
Armadillo (1720)	91	156,520	34	
Iguana/savanna lizard (1120)	97	108,640	24	
Anteater (1460)	59	86,140	19	
Turtle and bird eggs (2180)	48	104,640	22	
Bird (1700)	22	40,800	8	
Rabbit (1700)	2	3,400	1	
TOTAL GAME AND FISH	4,310	6,450,086	**1,392**	**68%**
VEGETABLES:				
'Hero' (1200)	1,011	1,213,200	262	
'Oyo' (682)	522	356,004	77	**ROOTS**
'Hewyna' (682)	314	214,148	46	
'Yatsiro' (1200)	20	24,000	5	
'No'o' (1200)	7	8,400	2	
Total roots:	1,874	1,815,752	**392**	**19%**
Ripe mangos (590)	537	316,830	68	
Green mangos (590)	112	66,080	11	
Palm nuts (2960)	30	88,800	19	**OTHER**
'Chiga' (4000)	12	49,640	10	
Oranges (393)	24	9,432	2	**VEGETABLE**
Mathenouto, uthuburu, umbobu (599)	14	8,386	2	
'Jojjom' fruit (599)	13	7,787	2	
'Guaye' fruit (599)	8	4,792	1	
Merei fruit (460)	7	3,220	1	
Palm heart (595)	7	4,165	1	
Waco fruit (599)	2	1,198	—	
HONEY (2673)	86	229,824	48	
Total other vegetable:	852	790,154	**165**	**8%**
TOTAL VEGETABLE:	2,859	2,609,460	**557**	**27%**
TOTAL ALL WILD FOODS:	7,169	8,658,752	**1,949**	**95%**

Continued on next page

Table 4—*Continued*

Resource name (cals/kg)	Amount (kgs)*	Total calories[1]	Mean daily per Capita consumption of calories[2]	Percent of the diet
AGRICULTURE:				
Plantain (1320)	31	40,920	8	
Corn (970)	8	7,760	2	
Auyama (350)	9	3,150	1	
TOTAL AGRICULTURE:	48	51,830	11	1%
STORE-BOUGHT FOOD AND GIFTS FROM OUTSIDERS:				
Beef (1785)	124	221,340	47	
Rice (3640)	36	131,040	28	
Spaghetti (1107)	24	26,568	6	
Sugar (3840)	1	3,840	1	
Corn flour (1890)	1	1,890	1	
STORE-BOUGHT TOTAL:	186	300,972	83	4%
TOTAL MEAN PER CAPITA OF CALORIES CONSUMPTION			2,043 cals	

[1]Kilograms × number of calories per EDIBLE kilogram.
[2]There were a total number of *4635 consumer-days* for the entire sample period. Consumers were defined as all individuals over the age of 3.5 years.
*Edible portion only.

plants contributed comparatively less to food intake, the wild plant foods category is in turn divided into roots and other plant foods.

Major categories are ranked according to their relative caloric contribution to the diet (from highest to lowest), and resources within each category are ranked in the same way. The number of edible kilograms of each resource acquired during the entire sample period is listed along with the total calories calculated for each resource using the values for calories/edible kilogram shown on Table 3. The total number of edible kilograms for each food item brought into camp was multiplied by the number of calories per kilogram listed in Table 3. These totals in combination with the sum of the number of consumers present in camp for each day sampled allowed us to estimate the number of calories consumed per person-day by the average Hiwi individual for the entire sample period (3,635 consumer-days). It is important to note that this mean is weighted by sample day rather than weighted seasonally. "Consumers" were defined in this study as individuals over the age of 3.5 years.[6]

Table 4 shows that meat was an important source of food energy in the Hiwi diet during the period that was sampled. It was probably the main contributor of protein and lipids as well. Sixty-eight percent of the total caloric intake came from game and feral domestic animals. Capybara, feral animals,[7] and fish each provided 200 calories or more per consumer-day. These were followed in importance by caiman, peccary, deer, turtles, armadillo, iguana, and anteater, each providing more than 50 calories per consumer-day, and finally, by turtle eggs, birds, and rabbit, which each provided fewer than 50 calories per consumer-day. A total of 1,392 calories per consumer-day was derived from meat. This amounts to a mean daily per capita consumption of 930 grams of edible meat.

Collected foods accounted for 27 percent of the daily caloric intake of Hiwi foragers (557 calories). Roots provided the highest percentage of the plant food calories acquired (19 percent, or 392 calories), with "hero" root, a small wild potato, being the most important (mean daily per capita consumption = 262 calories). Less food energy per consumer-day was derived from the "oyo," "hewyna," "yatsiro," and "no'o" roots (<80 calories each). Only 8 percent of mean daily per capita consumption of calories came from other plant resources (165 calories per day). Ripe mangoes provided more food energy to the Hiwi than any other fruit, but this was still less than 100 calories of the mean daily per capita consumption. All other fruits were of minor importance (<20 calories each per consumer-day). Finally, honey (48 calories per consumer-day) accounted for about 2 percent of the daily energy consumption of Hiwi foragers.

The results show that wild plant and animal foods were the source of most of the Hiwi's food energy during our study. The mean daily per capita consumption of these resources was 1,949 calories per consumer-day, or 95 percent of the total. The remaining 5 percent of food energy can be attributed to store-bought foods and agricultural products, with store-bought resources providing more of the daily caloric per capita consumption (4 percent, 83

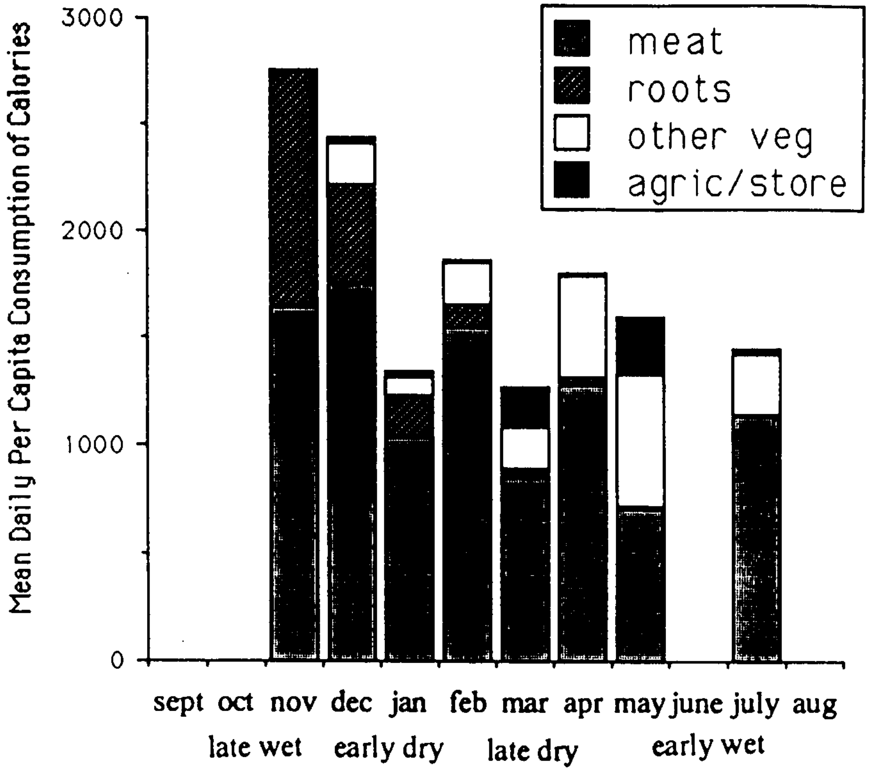

Figure 3a. Mean Daily per Capita Consumption of Calories among Hiwi Foragers across Months

calories) than agricultural products (1 percent, 11 calories). The sum total of the calories consumed per person-day among the Hiwi during our sample period was *only 2,043 calories.*

These analyses of the diet suggest that the Hiwi population we studied was essentially a foraging population who depended on hunting and gathering for most of their food energy during our study. Most importantly, game, rather than plant foods, appears to have been their main source of energy, as well as of protein and lipids.

Seasonal Variation in the Diet

Figures 3a and 3b illustrate changes in the mean daily per capita consumption among Hiwi foragers across months and seasons of the year respectively. In order to calculate mean daily per capita consumption for these analyses, we summed the number of calories acquired on a given day and divided the total by the number of consumers present in camp on that day. Each of these daily means was then summed and divided by the total number of days in a seasonal sample in order to arrive at the mean daily per capita consumption of calories for that season.

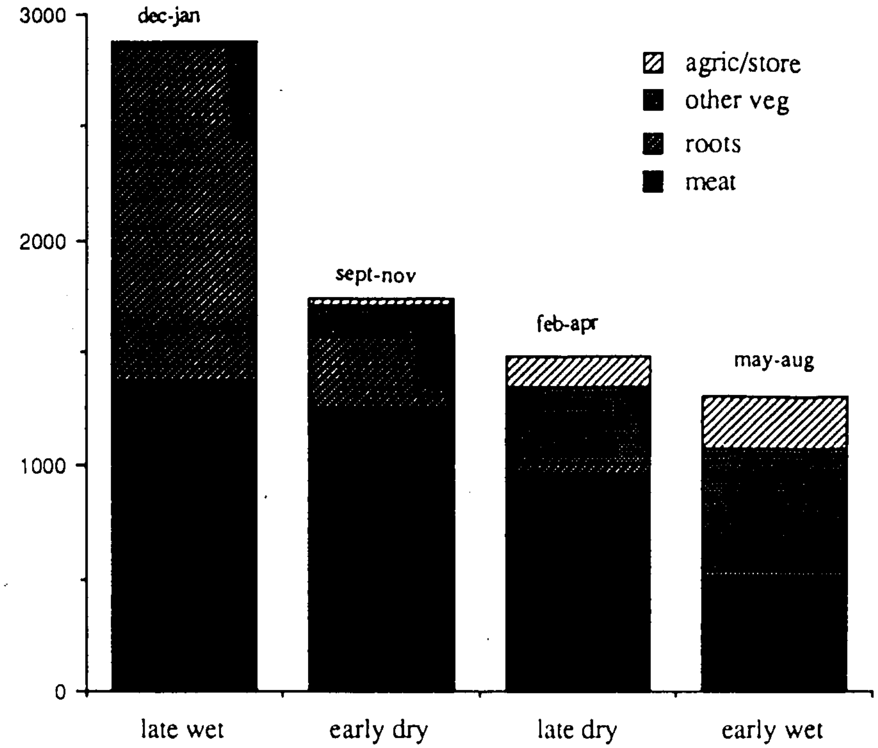

Figure 3b. Mean Daily per Capita Consumption of Calories among Hiwi Foragers across Seasons

In order to evaluate whether our measured mean differences in the daily mean per capita consumption of calories across seasons were likely to be real or due to sample error and random fluctuation, we ran two-tailed one-way ANOVAs (the samples were normally distributed). The results are presented in Table 5. This table includes the daily mean per capita consumption for each season across the top rows corresponding to each food type and the mean difference in mean daily consumption of calories between pairs of seasons in the boxes beneath. Within- and between-group analyses of variance of mean daily per capita consumption across seasons and according to resource category do not allow us to reject the hypothesis that mean seasonal differences in total calories derived from all foods were due to sample error during our sample period (p = .123, two-tailed). Seasonal differences in consumption of meat and agricultural products were also shown not to be statistically significant. It is nevertheless interesting to note that the late wet season shows a higher mean per capita consumption (>2,500 calories) than other seasons (mean <2,000) (Table 5), since Hiwi informants claim that this is the season of highest food availability.

Meat consumption did not seem to contribute to seasonal differences in total

TABLE 5
Mean Difference in Daily Mean Per Capita Consumption of Calories across Seasons

SEASONS	EARLY DRY	LATE DRY	EARLY WET	LATE WET	
	ALL FOOD				ANOVA
	mean = 1735 SE = 282 n = 26	mean = 1448 SE = 286 n = 24	mean = 1350 SE = 220 n = 12	mean = 2756 SE = 473 n = 15	F-test = 1.99 p = .123
EARLY DRY		−297	−460	1026	
LATE DRY			−180	1200	
EARLY WET				1460	
	MEAT				ANOVA
	mean = 1247 SE = 234	mean = 957 SE = 151	mean = 509 SE = 201	mean = 1378 SE = 202	F-test = 1.779 p = .1583
EARLY DRY		−290	−739	−278	
LATE DRY			−449	−120	
EARLY WET				505	
	ROOTS				ANOVA
	mean = 322 SE = 129	mean = 58 SE = 24	mean = 5 SE = 17	mean = 1478 SE = 331	F-test = 8.439 p = .0001
EARLY DRY		−265	−317	1074	
LATE DRY			−53	1380	
EARLY WET				1431	
	OTHER VEGETABLE				ANOVA
	mean = 135 SE = 79	mean = 325 SE = 345	mean = 559 SE = 129	mean = 15 SE = 13	F-test = 8.524 p = .0001
EARLY DRY n = 26		189	502	−122	
LATE DRY n = 24			313	311	
EARLY WET n = 12				−624	
	AGRICULTURE				ANOVA
	mean = 17 SE = 10	mean = 13 SE = 6	mean = 0	mean = 6 SE = 23	F-test = .781 p = .5082
EARLY DRY		−4	−17	−11	
LATE DRY			−13	−17	
EARLY WET				6	
	STORE-BOUGHT				ANOVA
	mean = 15 SE = 11	mean = 125 SE = 61	mean = 229 SE = 126	mean = 2 SE = 2	F-test = 2.902 p = .0407
EARLY DRY		110	214	−14	
LATE DRY			105	−123	
EARLY WET				−228	

energy consumption even though the composition of animal species in the Hiwi diet varied dramatically across the year. For example, during the dry season months, the Hiwi consumed twice the amount of fish that they consumed in the wet period (p = .048, two-tailed t-test), and yet this difference is not reflected in the overall caloric intake of energy derived from meat. This occurs because the Hiwi acquired other animal species such as turtles and capybaras during the wet season.

In contrast to meat, roots and other wild plant foods were highly seasonal food staples (p = .0001, two-tailed ANOVA; Table 5). Calories derived from roots peaked during the late wet season, and those derived from other wild plant foods peaked during the early wet season. During the wet season, then, the Hiwi consumed larger quantities of carbohydrate foods than in the dry season.

Among the less important categories, store-bought foods showed significant high seasonal variance, while agricultural products did not. Even though the Hiwi ate store-bought foods in small quantities throughout the year (<300 cals/consumer-day), they tended to consume significantly more of these foods during the early wet season than at other times, primarily because of the presence of local tourists in the region in May (p = .0407, two-tailed ANOVA). The contribution of agricultural foods was too small to adequately detect significant seasonal differences.

The above analyses allow us to divide the annual cycle according to the main plant foods that are acquired across seasons. In our sample, the seasons can be characterized as the root season (late wet), the mango/chiga season (early wet), and a long dry season of scarce plant resources. This variation in the consumption of plant foods may have important biological implications. Consequently, in addition to the rainfall criteria used above, labels that reflect this variability will also be used in the analyses of sex differences in subsistence strategies, nutritional status, and fertility across seasons.

THE SEXUAL DIVISION OF LABOR

The annual food consumption cycle is the product of sex differences in subsistence strategies. Men and women acquired different types of foods, with different caloric values and in different quantities, as seasons changed. Sex differences in foraging effort were also unevenly distributed in time. In the following analyses only observations on men and women between twenty and fifty-five years of age are included.

Food Acquisition

Figures 4a and 4b show the monthly and seasonal variation in the number of calories that were acquired per day by Hiwi men and women. The late wet peak in Figure 4b suggests that the apparently more plentiful diet of the late wet season was due to greater caloric acquisition by Hiwi women during this time relative to other seasons.

We disaggregated the data on women's caloric acquisition and foraging effort (see below) into two groups: nonnursing and postreproductive women, and nursing and pregnant women (see Tables 6–9, below). We did this because we are interested in determining whether females who are in a reproductively costly state (nursing and pregnant women) experience greater health costs as a result of increases in work effort or low food consumption than do women

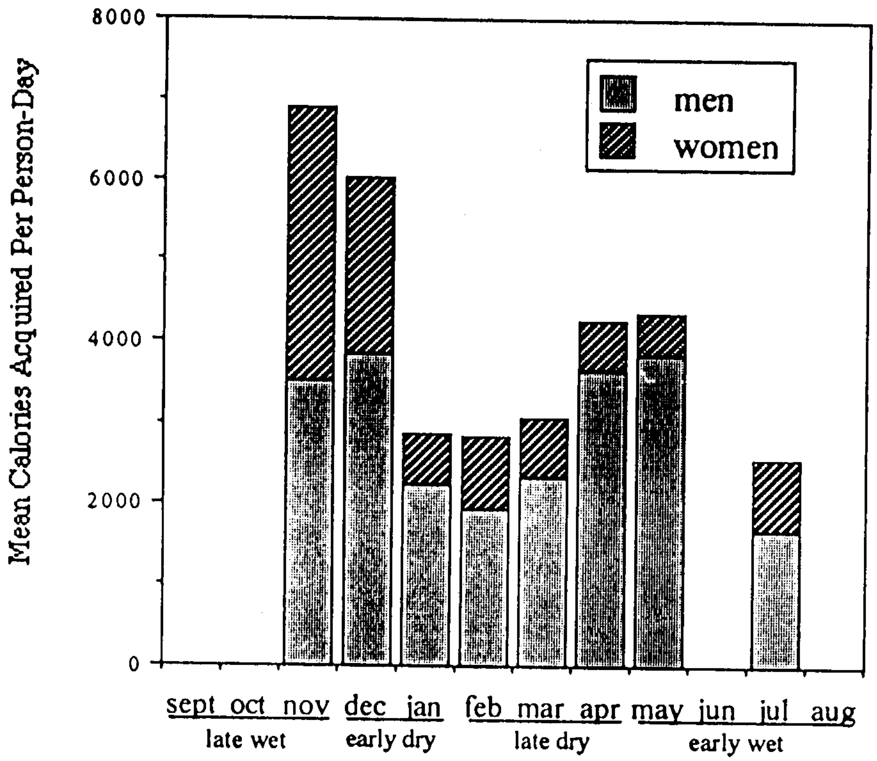

Figure 4a. Mean Number of Calories Acquired per Person-Day among Hiwi Men and Women across Months

who are experiencing relatively low reproductive costs (nonnursing and postreproductive women). We have lumped our observations on postreproductive and nonnursing women because preliminary analyses showed that changes in their foraging behavior were very similar across seasons. This was also true of nursing and pregnant women (Hurtado and Hill 1990).

"Postreproductive" and "nonnursing" women include those individuals who had not experienced a pregnancy over the past five years and whom we estimated to be over forty-five years of age and those women of reproductive age who were not lactating over the period sampled. "Nursing" and "pregnant" women are individuals who were lactating during the month when behavioral observations took place or who were pregnant.

Sex Differences. The average Hiwi man produced significantly more calories per person-day than did the average Hiwi woman in all seasons except for the late wet season when roots were in the diet (Table 6). In the dry season, men acquired just fewer than 3,000 calories per person-day, while in the wet season, they acquired over 3,000 calories. The women, on the other hand, produced fewer than 1,500 calories per person-day (range = 420–1,171) during the dry

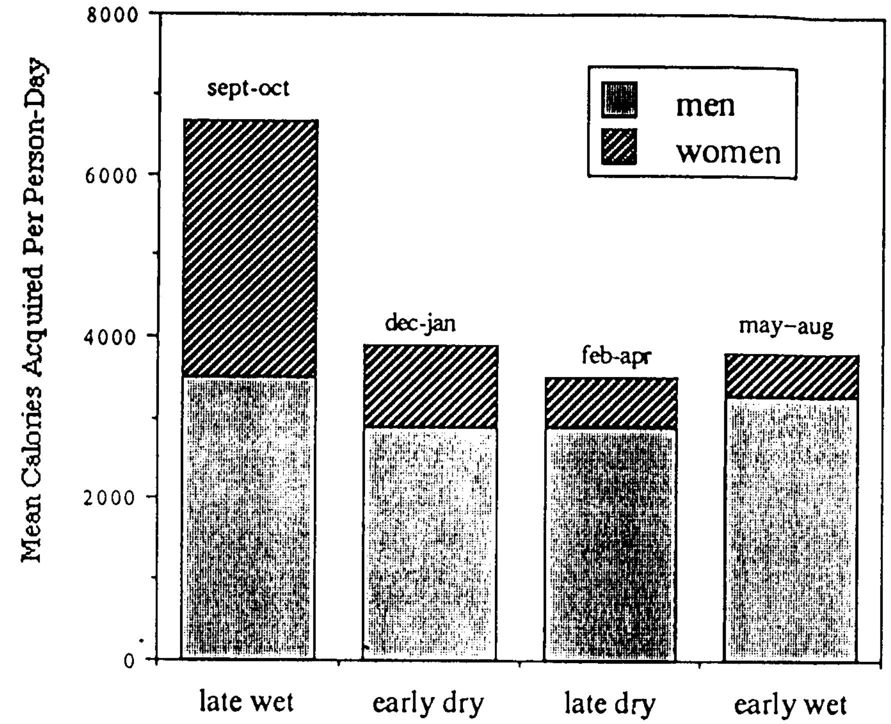

Figure 4b. Mean Number of Calories Acquired per Day among Hiwi Men and Women across Seasons

and early wet seasons. In the late wet season, however, they acquired a mean of over 3,000 calories per woman-day (Table 6).

Seasonal Differences. Table 7 shows seasonal differences in the number of calories that men and women acquired from the point of view of each sex. Because the data are normally distributed, we used one-way ANOVAs to test for significance levels. This table includes the mean number of calories acquired per person-day for each season across the top rows corresponding to each sex and the mean difference in the mean number of calories acquired per person-day between pairs of seasons in the boxes beneath. While Hiwi men's caloric acquisition was constant throughout the year (p = .6890, two-tailed), women's contribution was highly variable (p = .0215 and .0012, two-tailed) for nonnursing and postreproductive women and for nursing and pregnant women respectively.

Although men's caloric acquisition appears to have been constant across seasons, Hiwi men acquired significantly more fish in the dry season than in the wet season (see above). In addition, during the mango/chiga season (early wet season), Hiwi men's subsistence behavior deviated from the typical sexual division of labor pattern: the men did more than half the fruit gathering during